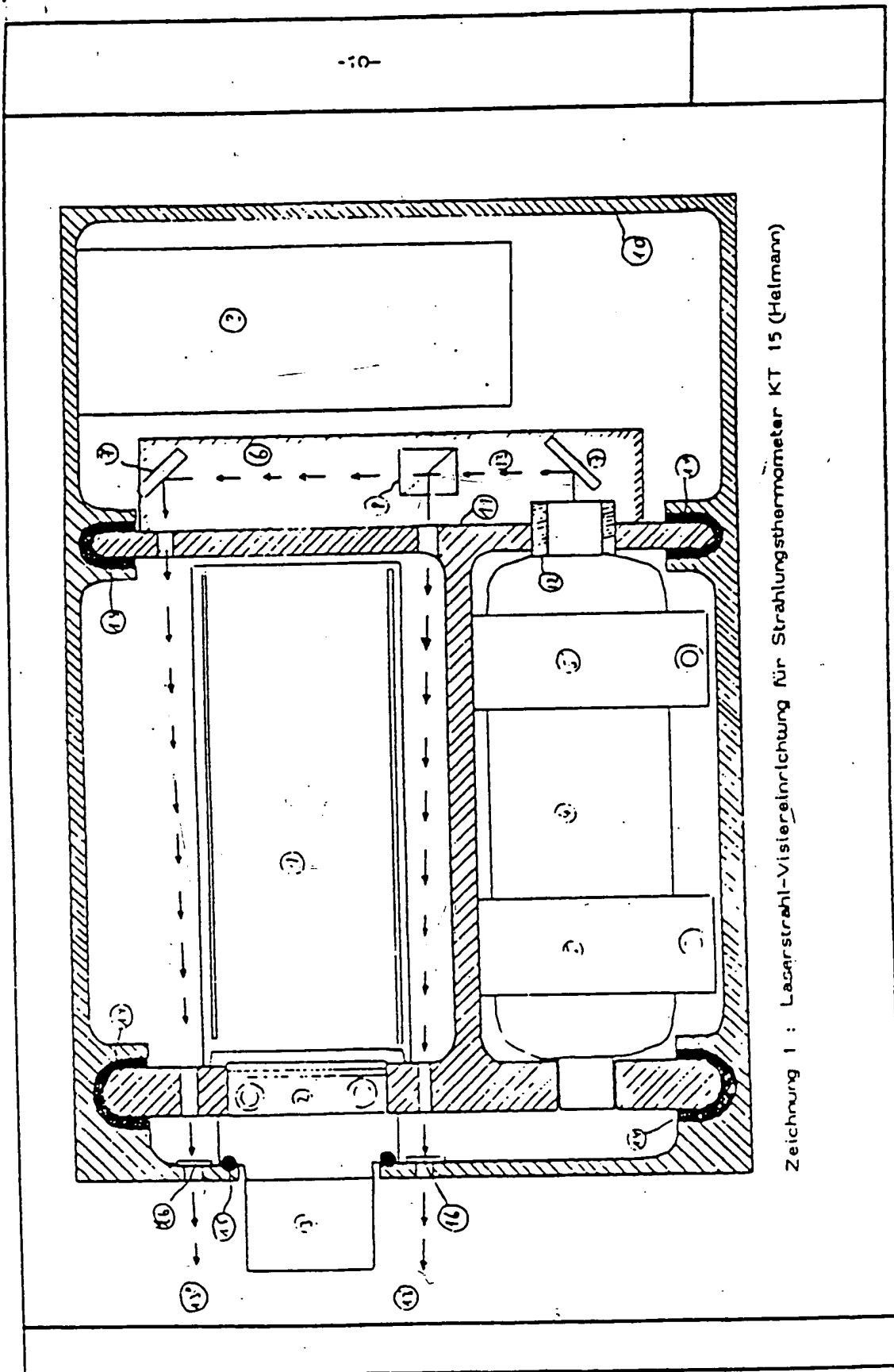


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A laser beam sighting device for marking position and diameter of the measurement spot for radiation thermometers with focal or afocal lens-and mirror optical system

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Radiation thermometers as convenient, predominantly battery-operated apparatus for non-contact measurement of the temperature of surfaces with the aid of the emitted thermal radiation are used not only in the laboratory but recently increasingly in mobile form for rapid survey measurements in machines of all kinds and also in production installations for monitoring and preventive inspection, but also in buildings from the inside and outside by day and night for matters of energy saving and locating damage.

As the maximum of the emitted thermal radiation at low temperatures far in infrared lies at approximately  $5 - 10 \mu$ , either one or more mirrors must be used for the optical system of these apparatus or lenses made from materials which are generally not transparent to visible light, such as, for example, germanium. Therefore, the problem is posed, in particular in the case of measurements at a distance of several metres, of making distinguishable for the user the position and size of the measurement spot or generally the course of the path of infrared measurement rays.

Simple radiation thermometers only have position marks on the outer housing wall; more costly apparatus with a mirror optical system have viewfinders or use a light mark from an imaged pilot lamp.

These solutions have distinct disadvantages for the said cases of use. With a mere position marking, no information is obtained as regards the measurement spot size, which as a rule increases rapidly. Viewfinders and a pilot lamp require an increased expenditure, in which the viewfinder is limited to favourable light conditions; it fails in the dark. The high power requirement of conventional lamps for a clearly visible illumination intensity in daylight generally rules out operation by battery.

An arrangement has been recently described (Laser Focus

Vol.8, pages 32-33, 1981), which combines a simple radiation thermometer - originally only equipped with position marks - with a HeNe laser for marking the smallest measurement spot. According to this not very detailed description, in this arrangement the laser tube is mounted externally on the housing of the radiation thermometer. The laser beam is divided into two partial beams and the first non-expanded beam is reflected into the path of infrared rays, so that it emerges paraxially. The second laser beam is expanded and runs somewhat staggered and obliquely to the axis of the radiation thermometer. In order to ensure a sharp infrared representation of the object under examination in the smallest measurement spot, the user has to vary the measurement distance so that the non-expanded laser beam sits centrally in the expanded one. As advantages of this arrangement, the substantially simplified targets are mentioned, and also the possibility of illuminating the object under poor light conditions.

Despite an enclosed sketch of the arrangement, many questions remain unanswered, e.g. concerning the nature of the ray expansion and also concerning the output power and voltage supply of the laser. It would be a great restriction of the usefulness of the originally battery-operated apparatus, if to achieve the necessary illumination intensity in the expanded beam a laser with mains supply would be necessary.

Whilst the angle of inclination of the two beams to each other is determined by the representation conditions of the radiation thermometer and the displacement of the beam centres to each other, the extent of the displacement itself is clearly purely accidental - presumably provided through the diameters of the housing and laser -, and in any case it is not obviously associated with the optical representation conditions, the distance relationship, the infrared optical system.

Owing to the type of reflecting of the non-expanded laser beam which is used, this arrangement is not able to be transferred to radiation thermometers with a lens optical system.

The problem is therefore posed, for radiation thermometers preferably with a lens optical system, of developing an active sighting device using a battery-operated HeNe laser having low power for marking the measurement spot, which distinctly marks both the position of the smallest measurement spot and also, in the case of greater distances, marks the aperture angle of the path of measurement rays, given by the distance relationship of the radiation thermometer. This sighting device is intended to manage without intervening in the optical system of the radiation thermometer, i.e. without using expensive transparent materials or the perforating of the germanium lens. It is to be light enough for lengthy mobile use by hand and, at the same time, is to be mechanically stable and protected from environmental influences, in order to be able to withstand hard use inside and out, and also shocks by being put down roughly without disadjustment. Furthermore, the entire apparatus is to be supplied from a battery, in which, despite the compact construction, disturbances of the electronics of the radiation thermometer through ignition and operation of the laser must be reliably ruled out. In addition, the laser beam sighting device is to be structurally designed so that the mass-produced radiation thermometers of various manufacturers can be integrated, in which no, or only a minimum number of mechanical or electrical modifications are necessary.

The problem is solved according to the invention for radiation thermometers with a "focal" infrared optical system representing at a finite distance, in that the beam (13) of a battery-operated miniature He-Ne laser of

approximately 1 mW output power is divided by beam splitters (8) into two non-expanded partial beams (13') and (13''), which in a plane with the optical axis of the infrared radiation thermometer emerge at a characteristic distance outside the infrared optical system (3) with an angle of inclination to each other corresponding to the distance relationship. In this novel beam guidance, the two beams intersect and thereby mark the position of the smallest measurement spot. At a greater distance they diverge with the angle divergence characteristic of the distance relationship of the radiation thermometer, so that the two red points of the non-expanded laser beams (13') and (13'') on the object under examination in each case designate a diameter of the measurement spot, the vertical one in the arrangement sketched in drawing 1. If simple glass optical systems without a special anti-reflex coating are used for beam splitter (8), deflecting mirror (7 and 7') and outlet window (16), the power of the emerging laser beams (13' and 13'') lies below 0.3 mW and is no longer dangerous for the eye, owing to the lid closure reflex if accidentally looked at directly. With this low output, the laser marks are visible in daylight on a light background, such as, for example, walls of buildings, at approximately 10 m, and in darkness at a measurement distance of approximately 20 m.

In the case of radiation thermometers with an "afocal" infrared optical system not representing at a finite distance, the laser beams emerge without intersecting each other with the divergence angle corresponding to the distance relationship. The matching of the divergence of the laser beams (13' and 13'') to the distance relationship of the radiation thermometer is carried out by rotating the beam splitter (8) and the deflecting mirror (7'), by way of additional assistance also the deflecting mirror (7), about their centre axes vertical to the beam plane and also by displacement on the mounting plane (6). For routine adjustment of the components (7, 7' and 8) to a particular

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distance relationship, the mounting plane (6) can be equipped with corresponding stops.

The mechanical-optical construction is realised according to the invention by a hermetically sealed outer housing (10), in which there is situated a mounting (11) in a floating suspension, with elastic intermediate pieces (14) e.g. of rubber, for shock absorption, for the rigid mounting of all optical parts with respect to each other. This mounting in the form of an "H", preferably of aluminium, divides the outer housing (10), likewise of aluminium or fibre-reinforced plastic, into several chambers, in which - in each case secured to the H-shaped inner part - the body of the radiation thermometer (1) is rigidly secured via the mounting (2), the laser tube (4) via the mountings (5) with the insulated passage (12) and also the optical components (8,7,7') on the mounting plane (6). The inner mounting (11) serves additionally both for electromagnetic screening and also for the distribution and removal of the heat generated by the laser tube. The hermetic sealing from the external world as a protection against dust and humidity is ensured by the outlet windows (16) and likewise in a floating manner by the O-ring (15). The power supply module (9) to supply the laser sits directly against the outer housing (10), for a better removal of heat.

In a further embodiment of the invention, the left-hand shank of the inner mounting (11) is constructed so that it can receive directly the body (1) of the radiation thermometer with the fastening (2), which the manufacturer of the radiation thermometer has provided as standard for mounting into its original housing. Thereby an integration of the whole family of radiation thermometers of a series with different temperature ranges and different focal and afocal optical systems into the laser beam sighting device is possible at a favourable cost and with reliability in operation.

For integration into the laser beam sighting device, only the body of the radiation thermometer, i.e. the optical-electronic functional unit, but not the outer housing, is required. It is an intermediate stage of mass production which is able to be recalled by the manufacturer in the required form; it can be dismantled from the original housing in adjusted and calibrated form from finished apparatus, e.g. in the case of re-equipping.

For the integration of the radiation thermometers of different manufacturers with deviating dimensions, in accordance with the invention only the dimensions of the housing (10) and of the mounting (11) are accordingly altered on the laser beam sighting device, whilst maintaining the basic structure and the beam guidance. In well constructed mass produced apparatus of the leading radiation thermometer manufacturers, no or only a few further mechanical alterations are necessary. Thus, in 3-5 laser beam sighting devices, which are different in dimensions but similar in construction, approximately 60 - 80 % of the commercial radiation thermometers for mobile use can be integrated preferably by hand.

Radiation thermometers with mirror optical systems are also basically able to be integrated.

Drawing 1 shows according to scale an example embodiment of the laser beam sighting device with an integrated radiation thermometer body from the KT 15 series of the firm Heimann GmbH, Wiesbaden. This series of apparatus together with special versions of identical construction, e.g. the series KT 14, having production numbers in five figures, is one of the best-introduced radiation thermometers on the market and, at the same time, is the most compact apparatus of its kind.



As HeNe laser, the miniature laser type LGR 7624 with power supply apparatus LGN 7457, manufactured by Siemens, is used which, according to the manufacturer's information, is the smallest mass-produced HeNe laser of its power class worldwide and is suitable for battery operation.

Hence the arrangement of the laser beam sighting device sketched in drawing 1, with the integrated radiation thermometer, represents the smallest and most compact combination apparatus that is able to be created with commercial components, having a weight of under 1 kg.

The battery (NiCd accumulator) and display instrument (digital display) are accommodated in a separate carrying case, with which the laser beam sighting device including the radiation thermometer are connected in a plug-in manner via a cable. For mobile use, a pistol grip for one-handed operation is arranged on the underside of the housing (10) beneath the centre of gravity. When required, the laser beam is switched on by means of a sending key. By means of a second independent sending key, the displayed temperature is stored for the duration of operation, so that aiming with the laser beam sighting device and reading of the temperature which is determined on the display are two decoupled activities.

The special advantages of a radiation thermometer with a laser beam sighting device in the indicated arrangement consist in the mechanical robustness, the low and ergonomically favourably distributed weight, which also makes possible a long-term use with only one hand, in which both eyes of the operator of the apparatus remain free. This point is particularly important for use in a dangerous environment, e.g. in the inspection of installations conducting a high voltage. The high illumination intensity of the laser beams, which are non-expanded but are not dangerous to the eyes, in connection with the battery

operation make possible a flexible use by day and night, inside and outside. Through the clearly marked position and size of the measurement spot under practically all light conditions, the security of measurement is improved. Also, persons accompanying the user of the apparatus can see the position of the measurement spot during the measurement, which represents an important advantage over conventional optical viewfinders in particular in the case of on-site investigations, e.g. for locating thermal weak sites in installations and buildings.

## Claims

1. A laser beam sighting device for marking the position and diameter of the measurement spot for radiation thermometers with a focal or afocal lens- and mirror optical system,

characterised in that through a device two non-expanded laser beams lying in one plane, having an intensity which is not dangerous to the eyes, with an angle to each other corresponding to the distance relationship of the infrared optical system of the radiation thermometer and therefore at a characteristic distance are directed past the infrared optical system externally without intervention so that the optical axis of the infrared optical system lies in the plane of the laser beams, which is achieved through mechanical integration of the body of the radiation thermometer into the device itself.

2. A laser beam sighting device according to Claim 1, characterised in that the device to carry out the guidance of the beam according to Claim 1 consists of a rigid inner mounting with mounting surfaces for the required optical parts, which is situated in a floating and shock-absorbed manner in an outer hermetically sealed housing.

3. A laser beam sighting device according to Claim 1 and 2, characterised in that according to drawing 1 for the integration of a radiation thermometer with focal lens optical system, in a manner which is favourably priced and reliable in operation, the inner mounting is additionally constructed so that the body of the radiation thermometer can be used directly with the original mounting device of the manufacturer.

4. A laser beam sighting device according to Claim 1 and 2, characterised in that for the integration of the mass-produced radiation thermometers of various

manufacturers, the dimensions of the inner mounting and of the outer housing and also the holding arrangement for the mounting device are modified specifically to the manufacturer whilst maintaining the basic construction and the beam guidance, so that with few laser beam sighting devices designed specifically to the manufacturer, the majority of the commercial mass-produced radiation thermometers can be integrated or re-equipped.

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Prüfungsantrag gem. § 44 PatG ist gestellt

Vorgezogene Offenlegung gem. § 24 Nr. 2 PatG beantragt

⑤ Laserstrahl-Visiereinrichtung zur Kennzeichnung von Lage und Durchmesser des Meßflecks für Strahlungsthermometer mit fokaler oder afokaler Linsen- und Spiegeloptik

32 13 955 Entfällt.

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